DREDGE'S BRIDGE, BATH.

THE TAPER CHAIN.

The principle I have introduced in the construction of suspension bridges, consists, as you will perceive by inspecting the above sketches, 1st. That the main chains of support should, instead of being parallel, or of the same size throughout, taper from the point of suspension to the centre of the bridge, in the manner as is represented in the plan of the chains, where the larger parts correspond with the points of suspension that rest upon the towers, at which part the sectional area of the iron is a maximum, or should be sufficient to resist, and sustain the tension caused by the weight of the bridge, and transit loads, whilst in the centre each chain is reduced in section to a single link. 2nd. That the rods or bars, which connect the roadway with the chains, are, instead of being in a perpendicular position, arranged in angles varying in extent from the towers of support where the rods are more perpendicular, to the centre of the bridge, where the angles in which they are placed become more acute.

The principle upon which these arrangements are founded, may be easily understood by tracing the action of the forces of a bracket when supporting a parallel weight. I do not intend that the comparison be mathematically correct, or to say that the straight boundary lines, or the action of the forces in a solid bracket be precisely the same in effect as the curved lines and mechanical arrangements of a bridge; but what I mean is this—that the principle which regulates the taper form for a bracket, also points out the propriety of adopting the same in the construction of a bridge; and as the principle is understood and acknowledged to be correct in the one, so, by comparison, we may demonstrate it to be correct in the other.

Suppose the bracket ABC fixed to a wall, or otherwise supported at the line AB, were required to support any parallel weight BCDE, attached to the under or horizontal side BC.

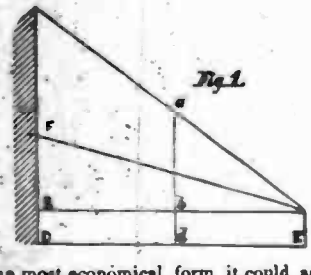


Fig. 1.

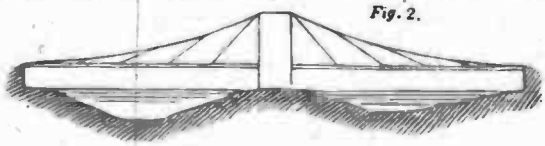
The most economical form it could assume to support that weight (of course neglecting the effect produced by the weight of the bracket itself), would be, a right angle triangle, the sides about the right angle of which being respectively represented by the lines AB and BC. That this form is mathematically correct, is evident from the following proportion.

$$ab : bcde :: AB : BCDE$$

or as the area of the section at any vertical line ab, is to the corresponding portion $bcde$ of the parallel weight resisted at that section, so is the sectional area at AB, or the base of the bracket, to the whole amount of the parallel weight sustained by it. From the point C draw the line CK, and suppose it to represent the neutral axis of the bracket, then will that portion ABC be on tension, whilst the remaining part, BEC, will have to resist the compressive force occasioned by the action of the vertical parallel weight BCDE.

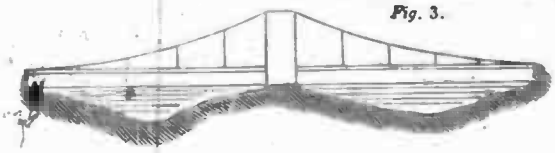
Now, we will imagine a case where it would be necessary to cross a river by placing the tower of support in the centre of the stream, and to support the roadway by means of two semi-curves, one deflecting from either side of the tower, as in fig. 2. It is evident, a bridge so constituted would be two similar and independent brackets, one projecting on each side of the central tower of support; now each of these brackets would have to sustain the parallel weight of a roadway; so that the principle that was demonstrated to be correct in the solid

Fig. 2.



bracket, would also, with equal force, apply to the instance just before us; and as it was shewn that the strain, and the material requisite to resist that strain, did, when constructed properly, decrease in regular ratio from the base to the end of the projection; so also ought the tension in the chains, and the dimensions of them, regularly to decrease from the points of suspension to the extremity, where both should become entirely evanescent. Such, however, is impossible, if the brackets were erected on the principle of the common catenary, with vertical suspending rods to convey the parallel weight of the roadway to the chains, as is represented by diagram fig. 3, for the tension in that case in the chains at the extremity of the bracket would be nearly as great as at the points of suspension; but if the suspending bars were arranged obliquely to the horizon, in the manner as shewn in fig. 2, then

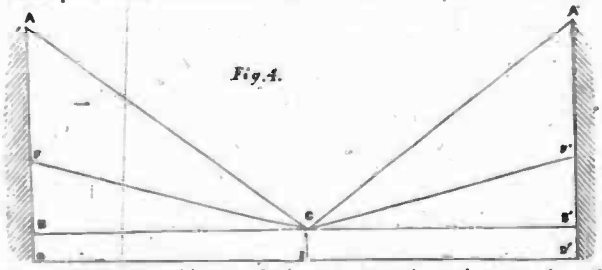
Fig. 3.



an effect altogether different would be produced; for, instead of the weight being conveyed to the chain at right angles to the horizon, it would be taken up and sustained in lines assimilating in direction towards the point of suspension, or, in other words, comparing it with the action of the bracket, the chains would perform the tension that is represented to be sustained by the action of the portion AEC above the neutral axis, whilst the roadway, or horizontal line, would perform that part of the duty represented in the solid bracket to be resisted by the material below the line CE. Thus, by the action of the oblique rods, the whole is harmoniously brought to act together; for the upper line or chain supports the tension, or what was supported by the upper portion of the bracket, whilst the lower line, or roadway, resists what was resisted by the lower part of the bracket; but when vertical suspending rods are used, the upper line, or chain, has to perform the whole of the duty; or if compared to the bracket, it would have to support on tension above the neutral axis those forces that should exist both above and below, which, being entirely contrary to the principles of nature, can only be accomplished with an immense sacrifice of material, and even then in an inefficient and unsatisfactory manner.

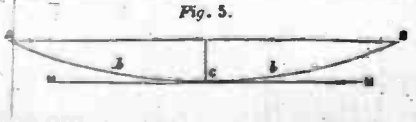
It would perhaps be more satisfactory to your readers if the general form in which bridges are presented to us, *viz.* that where there is a tower of support on each side of the river, and to follow out the illustration, let there be two similar brackets A B C, and A′ B′ C, projecting from opposite walls, A B, and A′ B′, conjoined at their extremities C, and each supporting a parallel weight BCDE, B′ C D′ E, as in fig. 4. Now each of these

Fig. 4.



brackets, though conjoined, are subject to the same forces as have been shewn to exist in them separately, and if they are divided in the same manner by similar lines drawn from the extremity of each to the points E E′, the several portions A E C, A′ E′ C, will represent the tensile, and E B C, E′ B′ C, the compressive force that exists in each of the brackets respectively. It has been shewn above that the area of a vertical section taken in any part of the bracket is always in proportion to the weight or force resisted at that section, and if sections be taken progressively from the base, they will continually decrease in magnitude till at the extremity of the projection the dimensions are entirely evanescent, and the forces existing there equally so. Now, if we conceive a bridge to be two brackets connected at their extremities, and springing from, as a base, the towers of support, one on each side of the space crossed, and supporting the parallel weight of the roadway for the transit of merchandize, &c., it should obtain the condition of the proposition, have no strain or tension at all at the centre of the chains, corresponding in the brackets to the point of junction C. But as I before said in reference to fig. 3, this cannot obtain in a structure built on the catenary principle, and for the reason there stated, *viz.* that the roadway is sustained and connected to the chains by vertical rods, from which cause the difference of tension between the centre of the chains and points of suspension is so trivial, as not to afford a sufficient compensation for the trouble of varying their sectional area in proportion to the variation of the tension. The effect and action of these rods on the curve or chains of a bridge may be easily understood thus:—Let A B, fig. 5, be the points of suspension of the curve A C B,

Fig. 5.



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